GU J Sci, Part B, 7(4): 497-504 (2019)

Gazi University

Journal of Science

PART B: ART, HUMANITIES, DESIGN AND PLANNING

http://dergipark.gov.tr/gujsb

DEVELOPMENT OF A DESIGN MODEL FOR THE FORMATION OF HIGH-SPEED TRAIN STATIONS

Selim YILDIRIM [1]

Arzu ÖZEN YAVUZ[1]

[1] *Gazi University, Architecture Faculty, Department of Architecture, 06570, Ankara, TURKEY*

Article Info

Received: 18/11/2019
Accepted: 10/12/2019

Keywords

Architectural Design, Architectural Configuration, High-Speed Train Station

Abstract

High-speed train station buildings are now becoming social centers for cities beyond being just a mode of transportation. In addition to being a gathering point that connects different railway networks, they became a focal point where the city and the city dwellers come together, almost acting as 'the gateway to the city'. In that sense, they are expected to meet different needs other than transportation. In order to meet daily needs, high-speed train station buildings are supported by spaces where people can spend time apart from transportation such as shops, diners, hotels and offices, thus, have become a social center of the city. In this regard, the high-speed train stations have become a multi-layered structure that incorporates different functions. The designers have used different methods and techniques to solve this multifunctional and multi-layered structure. Within the scope of this study, it is aimed to analyze the developed design approaches by examining different domestic and international high-speed train stations, and to develop a design model for new high-speed train stations to be built.

1. INTRODUCTION

Transportation, which is an indispensable part of daily life, is a major factor affecting society in terms of time, economy and sociality. Among the many modes of transportation that are being used today, it is inevitable for people to choose the most timely and economically appropriate option that responds to their wishes and desires. In this respect, railroad transportation offers a second alternative to air travel that people can safely choose to save a substantial amount of time. In many countries, high-speed train railway networks are frequently used in intercity passenger transportation, and the practice has become one of the most prominent preferences in Turkey as well.

One of the most important elements of railway transportation, which is seen as a significant transportation option in our country since the first years of the republic, is the train station buildings. The train station buildings play an important role as they show the development level of the country and make the first impression of the city. High-speed train station buildings are the welcoming places of the city and offer ideas about the identity of the city by displaying short films from the culture of the region. In this thesis, it is aimed to analyze how the concept of high-speed trains and incorporating multiple functions of daily life are approached in high-speed train station buildings; and to determine architectural design parameters for new high-speed train stations to be built within this context.

Within the scope of the thesis, domestic and international high-speed train station examples are analyzed through the architectural parameters that facilitate reading the design of a building such as functional organization, spatial organization, structure and material selection. Thus, it is aimed to generate new parameters for new high-speed train stations to be built in Turkey.

* Corresponding author: mmimar.selim@gmail.com

2. THE CONCEPT OF HIGH-SPEED TRAIN

Nowadays, countries have embarked on a quest of economic, comfortable, fast and safe transportation systems. The concept of high-speed train among other modes of transportation provides the most comfortable solution to the requests in that sense. The first high-speed railway line in the world was built in 1964 between Tokyo and Osaka in Japan. Afterwards, train networks including international routes and high-speed train stations in accordance with this network were constructed in many parts of the World [1].

Figure 2.1. Speed train network in Japan

Figure 2.2. Train network in Europe

Image 2.1. High-speed rail station and transit hub, Porta Susa TGV Station [2]

Image 2.2. The Hague Central Station [3]

High-speed train transportation has many advantages to differentiate it from other modes of transportation. To mention some of these [1];

- High-speed train transportation provides a great advantage in terms of time.
- While other modes of transportation such as automobiles, emit hazardous gases that contribute to global warming, environmental awareness occupy an important position in high-speed train transportation.
- It covers a relatively small area compared to the road transportation in terms of the area it occupies.
- High-speed train transportation system is of great importance in terms of energy efficiency. It is the most suitable transportation option against environmental and energy problems.
- It is a safer transportation mode in comparison to others.
- It is a convenient type of transportation for heavy loads.
- It plays a major role in alleviating the road traffic load.

In this study, it is aimed to examine the new advantageous transportation system and the high-speed train stations that meet the functional requirements regarding their relationship with the city.

3. ANALYSIS OF HIGH-SPEED TRAIN STATION BUILDINGS

High-speed train stations, which serve as a distribution point connecting the train routes between different cities, have also been a focal point where the city and the citizen come together. Hence, how to design the high-speed train stations, which had to take on a multi-layered and multi-functional structure with this

character, has been the subject of research. Within the scope of this study, in order to determine the deficiencies and/or parameters for the new high-speed train stations, domestic and international examples were analyzed.

During the analysis phase, two international and two domestic high-speed train station buildings were selected. International examples were selected based on multifunctionality and integration to the city due to the abundance and variety of high-speed railway networks. In Turkey, only two high-speed train station buildings have been built so far and consequently these have been assessed. The selected structures are firstly examined within themselves, with their plan, section, elevation and interior perspectives, they are discussed in detail; then, the comparative analysis of the common and different aspects of the high-speed train station buildings were determined in efforts to generate the architectural design parameters.

Train stations are analyzed under the following parameters:

- Functional analysis
- Spatial analysis
- Technical / technological analysis

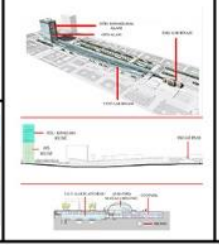
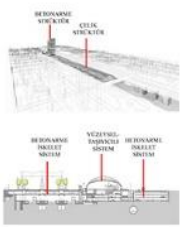
that affect the formation of a space.

High-speed train stations have become a social place for the city by incorporating many other functions beyond transportation. Under the title of Functional Analysis, additional potential initial design phase proposals of functional alternatives or varieties are investigated by determining the functions they incorporate. In the Spatial Analysis stage, how different functions come together with space organization is examined. Issues regarding natural ventilation, natural lighting, thermal comfort and acoustics that provide spatial comfort for a multi-functional and multi-layered structure design are analyzed as well. Under the title of Technical/Technological Analysis, structural systems and facade materials used in the iconic high-speed train stations are discussed in detail.

3.1. Examples From Around The World

Porta Susa TGV Station

Table 3.1. Analysis of Porta Susa TGV Station

BUILDING				FUNCTIONAL ANALYSIS					SPATIAL ANALYSIS					TECHNICAL / TECHNOLOGICAL ANALYSIS													
									SPACE ORGANIZATION	COMFORT CONDITIONS				FACADE MATERIAL							STRUCTURE						
PORTA SUSA TGV STATION	TURIN / ITALY	2014	AREP & AGOSTINO MAGNAGHI	TRANSPORTATION	ACCOMMODATION	SHOPPING	OFFICE	URBAN TRANSPORTATION	MULTI-FUNCTIONAL SINGLE SPACE	NATURAL VENTILATION	NATURAL LIGHTING	THERMAL COMFORT	ACOUSTIC	WOODEN	STEEL	REINFORCED CONCRETE	PLASTIC	GLASS	ALUMINUM	MEMBRANE	MASONRY	SKELETON	ORTHOTROPIC	TENSILE	SPACE FRAME	CURVED	FRACTAL	GEOMETRIC
NAME	LOCATION	YEAR	ARCHITECTURE	■	■	■	■	■	■	■	■	■			■	■		■	■			■	■					
																												

The architectural project of the building was co-designed by AREP and Agostino Magnaghi and Silvio d'Ascia and was built in 2014 in Turin, Italy (Table 3.1) [2].

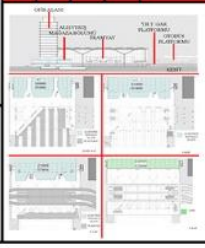
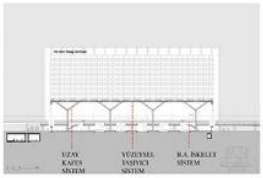
In addition to high-speed train transportation, the structure forms a whole with other transportation networks of the city such as subway and bus. The main function of this structure is transportation and waiting. Due to being a gathering point of different transportation networks, passengers are in need of different functions for both waiting and spending time. Therefore, it has turned into a social center for the city with its different functions such as shopping centers, office spaces and hotels [2].

The design incorporates spatial richness as well. Different functions come together with homogeneous transitions under a single shell. The common space configuration under a single shell defines a pattern that connects different transportation networks, different layers of the city and different functions. Natural ventilation and lighting set an important parameter in the design in terms of comfort within the space. Natural lighting and natural ventilation are easily provided by means of the designed transparent shell [2].

The desire to gather different functions under a single shell and to transmit natural lighting to all layers of the structure has necessitated the use of transparent, permeable material in the shell design especially at the façade. For this reason, glass is used as the façade material and steel is used for the structure to carry the glass. The idea of gathering under a single structure and transparency also affected the structural system, and thus, the shell of the structure is designed as an orthotropic structure system. The platform that provides the divisions within the structure or the relations between layers is constructed with reinforced concrete skeleton system [2].

The Hague Central Station

Table 3.2. Analysis of The Hague Central Station

BUILDING				FUNCTIONAL ANALYSIS					SPATIAL ANALYSIS					TECHNICAL / TECHNOLOGICAL ANALYSIS															
									SPACE ORGANIZATION	COMFORT CONDITIONS				FACADE MATERIAL							STRUCTURE							
THE HAGUE CENTRAL STATION	BIRMINGHAM / ENGLAND	2016	BENTHEM CROUWEL	TRANSPORTATION	ACCOMMODATION	SHOPPING	OFFICE	URBAN TRANSPORTATION	MULTI-FUNCTIONAL SINGLE SPACE	NATURAL VENTILATION	NATURAL LIGHTING	THERMAL COMFORT	ACOUSTIC	WOODEN	STEEL	REINFORCED CONCRETE	PLASTIC	GLASS	ALUMINUM	MEMBRANE	MASONRY	SKELETON	ORTHOTROPIC	TENSILE	SPACE FRAME	CURVED	FRACTAL	GEOMETRIC
NAME	LOCATION	YEAR	ARCHITECTURE																									
																													

The architectural design project of the building was carried out by Benthem Crouwel in 2016 in Birmingham, West Midlands, United Kingdom (Table 3.2) [3].

In addition to high-speed train transportation, the structure forms a whole with other transportation networks of the city such as subway and bus. The main function of this structure is transportation and waiting. Due to being a gathering point of different transportation networks, passengers are in need of different functions for both waiting and spending time. Therefore, it has turned into a social center for the city with its different functions such as shopping centers, office spaces and hotels [3].

Shopping, inter-city and inner-city transportation spaces come together under a single shell while the office and accommodation units are located in the second block. Thus, daily and special usage areas are separated from each other. However, there is a connection between the two. Natural ventilation and lighting set an

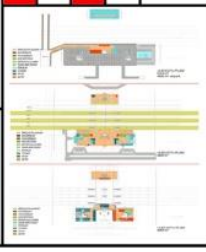
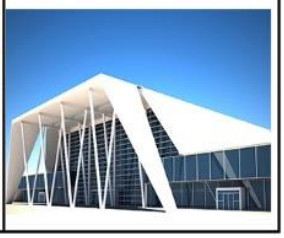
important parameter in the design in terms of comfort within the space. Natural lighting and natural ventilation are provided easily by means of the designed transparent shell. Elements for thermal comfort and daylight control have been designed as well and acoustic measures have been taken in the large common space [3].

Especially the space for daily life and transportation is designed transparent and permeable since it defines a common space configuration, a distribution and a gathering space. For this reason, glass, steel and concrete are used as façade materials in the building and the façade is enriched with the elements designed for solar control. To increase the span while passing through transparent elements and the solar control, space frame and orthotropic structural systems are employed on the shell of the common spaces. The platform separating the functions of transportation, waiting and shopping is a reinforced concrete frame system [3].

3.2. Examples From Turkey

Konya High-Speed Train Station

Table 3.3. Analysis of Konya High-Speed Train Station

BUILDING				FUNCTIONAL ANALYSIS					SPATIAL ANALYSIS					TECHNICAL / TECHNOLOGICAL ANALYSIS															
									SPACE ORGANIZATION	COMFORT CONDITIONS				FACADE MATERIAL							STRUCTURE							
KONYA HIGH-SPEED TRAIN STA.	KONYA / TURKEY	2011	TH & IDIL ARCHITECTURE	TRANSPORTATION	ACCOMMODATION	SHOPPING	OFFICE	URBAN TRANSPORTATION	MULTI-FUNCTIONAL SINGLE SPACE	NATURAL VENTILATION	NATURAL LIGHTING	THERMAL COMFORT	ACOUSTIC	WOODEN	STEEL	REINFORCED CONCRETE	PLASTIC	GLASS	ALUMINUM	MEMBRANE	MASONRY	SKELETON	ORTHOTROPIC	TENSILE	SPACE FRAME	CURVED	FRACTAL	GEOMETRIC
NAME	LOCATION	YEAR	ARCHITECTURE																									
																													

The architectural design project of the building was started in 2011 by TH and İDİL Architecture in Konya (Table 3.3) [4].

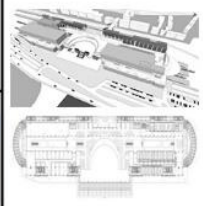
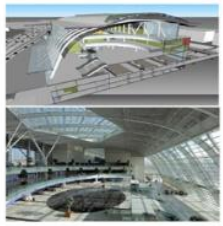
The building is designed to mainly function for transportation. Therefore, it includes high-speed train waiting and entraining spaces. There are also boutique eating and drinking units in the building [4].

The waiting and shopping functions gathered in a single space are distributed homogeneously. However, the train waiting stations are behind the structure. The character of being a gateway to the city is emphasized with wide eaves. Natural lighting and ventilation within the space are given importance [4].

With the developing technology, the choice of materials and structures is of great importance for the buildings. In this structure, glass and steel are used as façade materials. Skeletal and orthotropic structural system are chosen as the structural system [4].

Ankara High-Speed Train Station

Table 3.4. Analysis of Ankara High-Speed Train Station

BUILDING				FUNCTIONAL ANALYSIS					SPATIAL ANALYSIS					TECHNICAL / TECHNOLOGICAL ANALYSIS														
									SPACE ORGANIZATION	COMFORT CONDITIONS				FACADE MATERIAL							STRUCTURE						
ANKARA HIGH-SPEED TRAIN STA.	ANKARA / TURKEY	2015	A ARCHITECTURAL DESIGN	TRANSPORTATION	ACCOMMODATION	SHOPPING	OFFICE	URBAN TRANSPORTATION	MULTI-FUNCTIONAL SINGLE SPACE	NATURAL VENTILATION	NATURAL LIGHTING	THERMAL COMFORT	ACOUSTIC	WOODEN	STEEL	REINFORCED CONCRETE	PLASTIC	GLASS	ALUMINUM	MEMBRANE	MASONRY	SKELETON	ORTHOTROPIC	TENSILE	SPACE FRAME	CURVED	FRACTAL	GEOMETRIC
NAME	LOCATION	YEAR	ARCHITECTURE																									
																													

The architectural project of the building was designed by A Architectural Design and was opened in 2016 in Ankara (Table 3.4) [5].

The design, which aims to meet the contemporary desire of high-speed train stations to be a social place, incorporates many functions in itself other than transportation. Despite the main function being transportation, the structure has turned into a social center for the city with its usage for shopping, office and hotel purposes [5].

The design incorporates spatial richness as well. Transportation, shopping, office and accommodation units are solved under the same shell. To emphasize the gateway to the city, the central part of the prismatic structure is emptied and the entrance hall was projected to the outside at a different angle. Different functions are gathered with homogeneous transitions under a single shell. The common space configuration under a single shell defines a pattern that connects different transportation networks, different layers of the city and different functions. Natural ventilation and lighting set an important parameter in the design in terms of comfort within the space. The designed shell becomes transparent from time to time and thus, natural lighting and natural ventilation are easily provided. Various measures have been taken in terms of thermal comfort and acoustics [5].

With the developing technology, the choice of materials and structures is of great importance for the buildings. In this structure, mainly glass and steel are used as façade materials. Glass is used to control light in the common space. When the structural system is examined, the platform is constructed with reinforced concrete skeleton system and the shell is composed of orthotropic structure, space frame and arc geometric systems.

3.3. Evaluation

When all examples are analyzed together, it is seen that intersection with the inner-city transportation is given importance in design, especially in international examples. As high-speed train stations operate as a distribution point connecting different cities, multifunctionality is also essential. In Turkey, only Ankara High-speed Train Station is designed to be multifunctional since it serves as a distribution point of inter-city transportation that connects many cities, however, inner-city transportation is off the beaten path. In terms of space, in international examples it is important to unite under a single space while there is a distinction in Turkey.

The high-speed train stations have been analyzed due to the development of railway transportation with the developing technology, the increase in the population density and emerging preference for high-speed trains. Firstly, the development of railway transportation and its history has been analyzed. Analyses have been made on the advantages of railway transportation. Then, the change and development of high-speed train stations throughout history and architectural design parameters of high-speed train stations in the world and in our country are evaluated. Finally, common and different aspects between the architectural design parameters of the buildings in Turkey and abroad have been revealed.

Table 3.5. Comparative analysis of high-speed train station examples from around the world and Turkey

Country			Examples from Around The World		Examples from Turkey	
Building			Porta Susa Tgv Station	The Hague Central Station	Konya High-Speed Train Station	Ankara High-Speed Train Station
Functional Analysis	Transportation		●	●	●	●
	Accommodation		●	●		●
	Shopping		●	●	●	●
	Office		●	●		●
	Urban Transportation			●		
Spatial Analysis	Space Organization		Multi-functional single space	Multi-functional single space	Multi-functional single space	Multi-functional single space
	Comfort Conditions	Natural Ventilation	●	●	●	●
		Natural lighting	●	●	●	●
		Thermal comfort		●	●	●
		Acoustic		●		●
Technical/Technological Analysis	Facade Material	Wooden				
		Steel	●	●	●	●
		Reinforced concrete	●	●		
		Plastic				
		Glass	●	●	●	●
		Aluminum	●	●	●	●
		Membrane				
	Structure	Masonry				
		Skeleton	●	●	●	●
		Orthotropic	●	●	●	●
		Tensile				
		Space frame		●		●
		Curved geometry				●
		Fractal geometry				

4. CONSLUSION

When the high-speed train stations in the world are examined, it is seen that they have gained significant innovations in terms of function. The station buildings have become social centers for the city; turned into complex spaces that are not limited to transportation services. They offer short films for people to get to know the city; include social spaces for eating, drinking and shopping where people can spend time and hotels where people can stay.

It is seen that they aim to gather more than one function under one single shell. The designed shell combines all spaces. Mezzanine floors in a single mass are designed to balance human/space ratio. The designed shell also defines the void to point to the train platform. This void also defines the space for transportation and

waiting for the train. In short, the void is a foyer that provides orientation. At the same time, considering the local climate conditions, large transparent surfaces are designed in the shell to provide natural lighting and ventilation in the space.

With the developing technology in the world, innovations in façade materials and the structure draw attention in the design of the high-speed train stations. Predominantly, long span structures made of steel are used. Steel and glass are preferred as façade materials.

With the exception of Ankara and Konya, modern high-speed train stations haven't been built in Turkey. Existing train station structures can no longer meet the evolving needs. They only offer railway transportation in terms of function. Structural potentials provided by developing technology are not utilized in the existing stations.

5. REFERENCES

[1] Angoiti, I.B. (2010). Introduction to High Speed Rail Development Around the World, *2010 High-Speed Rail Practicums,* APTA: North America

[2] SILVIO D'ASCIA ARCHITECTURE. (2014). *PORTA SUSA TGV.* Web:https://www.dascia.com/porta-susa-tgv-eng, Access date: 01.11.2019.

[3]archdaily. (2016). *The Hague Central Station / Benthem Crouwel Architects* Web:https://www.archdaily.com/782706/the-hague-central-station-benthem-crouwel-architects, Access date: 01.11.2019.

[4]TH İDİL MİMARLIK. (2013). *Konya Buğday Pazarı Tren Garı.* Web:http://www.thidilmimarlik.com/default.aspx, Access date: 01.11.2019.

[5]mimarizm MİMARLIK VE TASARIM YAYIN PLATFORMU. (2017). *Ankara Hızlı Tren Garı* Web:http://www.mimarizm.com/mimari-projeler/ulasim/ankara-hizli-tren-gari_128027, Access date: 01.11.2019.

[6] Bülbül, E. "Stadyum Yapılarındaki Strüktür Sisteminin Biçim Oluşumuna Etkisi", Msc Thesis, Gazi University, 2017

[7]Önal, T. "Havalimanı terminal binalarındaki strüktürel sistem gelişiminin biçime etkisi ve analizi", Msc Thesis, Gazi University, 2015